AUSTRALIAN POST OFFICE

TECHNICAL TRAINING PUBLICATION

Engineering Training Group, 6 Flinders Street, Melbourne, Victoria, 3000

RURAL AUTOMATIC EXCHANGES (R.A.Xs.)

(PREVIOUSLY CP 141)

GENERAL DESCRIPTION ONLY.

1. INTRODUCTION.

1.1 The telephone requirements of subscribers in country areas are much the same as those of suburban subscribers, but because homes are more scattered, it is difficult to satisfy at reasonable cost the desire of country dwellers for a comparable service.

Small magneto manual switchboards are generally used to provide a service, these small exchanges being connected to the larger centres by trunk or junction lines. Most of these exchanges have less than 50 lines connected.

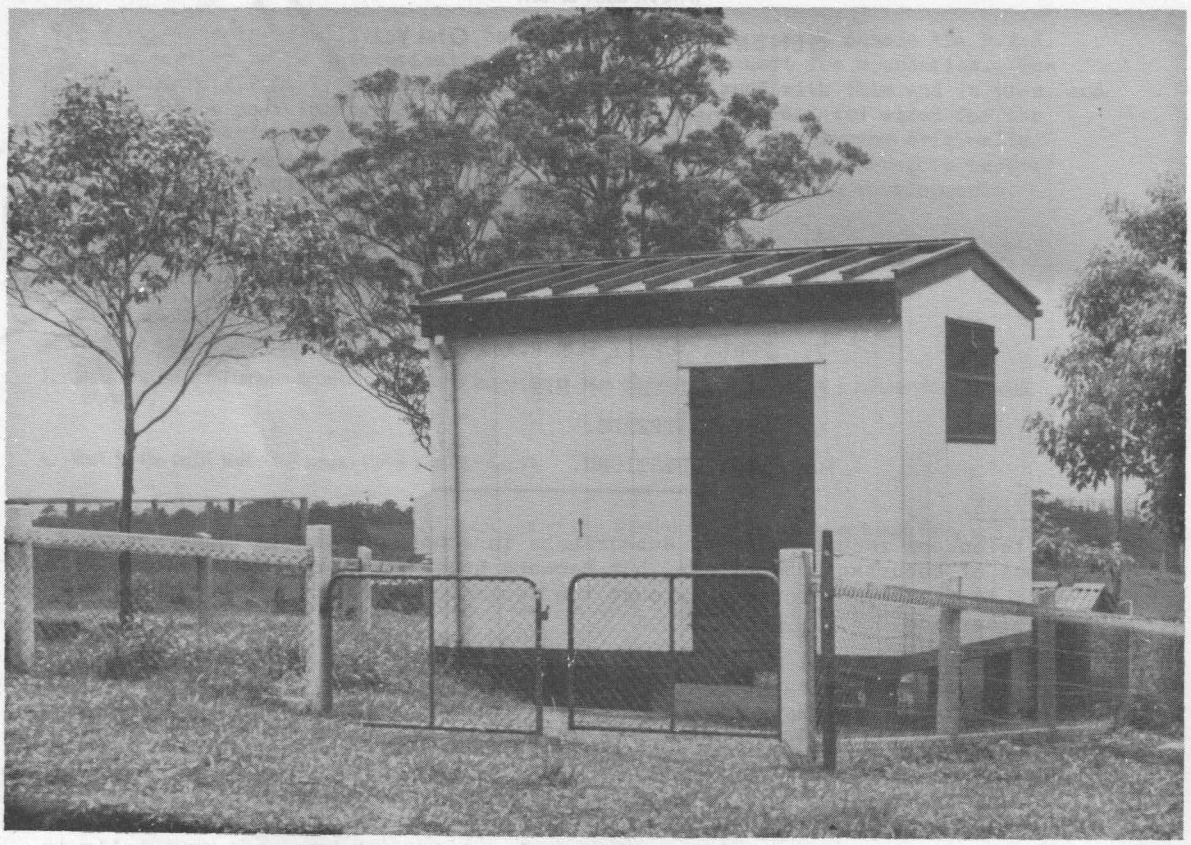
1.2 This arrangement has serious disadvantages. Usually, the exchanges are in the home of a subscriber who acts as telephonist (and often Post Office Keeper also), service being restricted to about 12 hours a day. An opening fee is then charged if service is required outside these hours. This is unsatisfactory for the subscriber who wants to use his service in his leisure hours, and especially in times of emergency.

Also the location of the exchange is determined by whoever is willing to accept the responsibility, and this rarely allows the most suitable layout of subscriber's lines. Any site away from the 'copper centre' means higher line construction costs.

As the number of subscribers connected increases, the hours of attendance may have to be extended, and this increases staffing difficulties.

Removals of country exchanges to other premises are frequent, involving heavy costs and possible interruptions to the service.

1.3 To overcome these difficulties, Rural Automatic Exchanges were developed. There are now over 1,000 R.A.Xs. in Australia, giving a continuous automatic service to more than 50,000 subscribers, and these figures are being increased rapidly. In many cases an R.A.X. replaces several manual switchboards. A typical R.A.X. is shown in Fig. 1.



TYPICAL R.A.X.

FIG. 1.

2. RURAL AUTOMATIC EXCHANGE (R.A.X.).

2.1 R.A.X. subscribers obtain connection to other parts of the telephone network, via trunk lines to a distant manual exchange known as the Parent Exchange. Direct access may be provided to adjacent manual exchanges, or other R.A.Xs. within the unit fee area. Fig. 2 shows the possible trunk line access for an R.A.X.; a large proportion of R.A.Xs. however, have access to the parent exchange only.

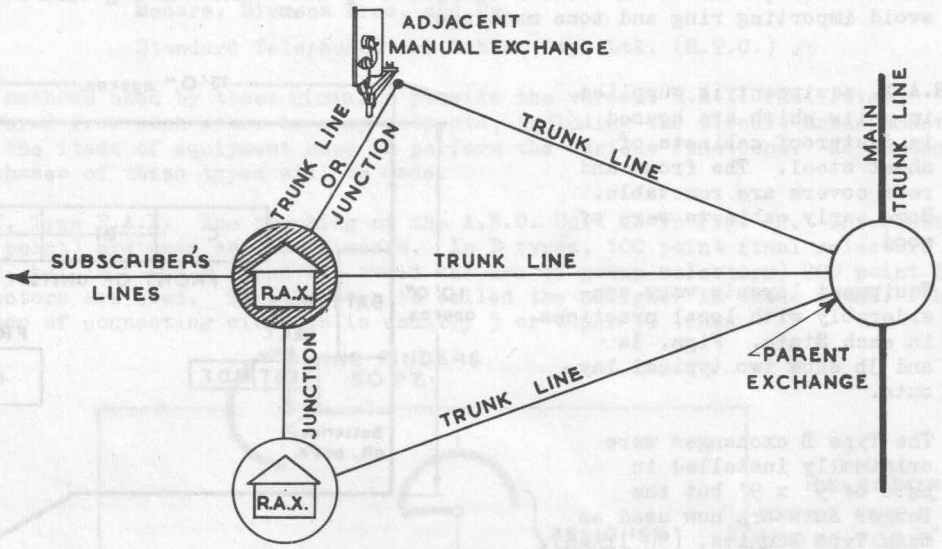


FIG. 2. TRUNK LINE ACCESS FOR AN R.A.X.

With the extension of multi-metering, direct access to subscribers outside the unit fee area will also be possible.

Reliability of operation is essential, as except for occasional maintenance visits, R.A.Xs. are unattended.

2.2 The R.A.X. is a complete exchange of up to 200 lines (or slightly over in a few cases) and includes batteries, charging plant, alarms, and in many cases testing facilities also. The equipment is housed in a small building having wooden or steel framing, with asbestos cement or galvanised iron sheeting externally, and asbestos cement or hardboard lining. In many cases, buildings are transported to the site fully assembled, and with most of the equipment installed.

2.3 Types of R.A.X. The first R.A.Xs. to be installed were designed in Great Britain. From experience gained with these units the Australian Post Office designed a unit more suited to our rural conditions. These were made by the British contractors, the first unit being installed in 1949 (Types C & D). A smaller unit was then designed in the A.P.O., the first of these being installed in 1951 (Type B).

The units are generally designated according to size and type -

Type B, for units with a capacity of up to 50 lines, but which cannot be extended beyond this number.
Type C, for units with a capacity of 50 lines, which may be extended to 200 lines (by adding type D units).
Type D, for 50 line units used for extending type C installations.

NOTE: The units designed by the equipment makers were sometimes referred to by the above designations, but more frequently by the name of the maker, for example - S.T.C. 50/200 line, or G.E.C. 50 line. Thus, the terms 'Type B', or 'Type C', have generally come to be regarded as referring to the standard A.P.O. units.

The Type B unit was made distinct from Type C, as a more compact and less costly unit can be made when the equipment is restricted to the needs of 50 subscribers. Actually the A.P.O. type B caters for a maximum of 40 subscribers plus 5 trunk lines.

Since 1954 branches of the British firms have been manufacturing the A.P.O. units in Australia, some of the common equipment of the C unit having been modified to avoid importing ring and tone machines.

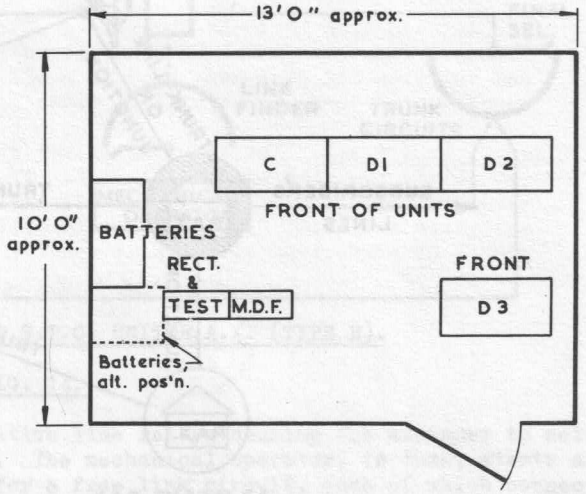
2.4 R.A.X. equipment is supplied in units which are housed in dustproof cabinets of sheet steel. The front and rear covers are removable. Some early cabinets were of wood.

Equipment layouts vary considerably with local practices in each State. Figs. 3a and 3b show two typical layouts.

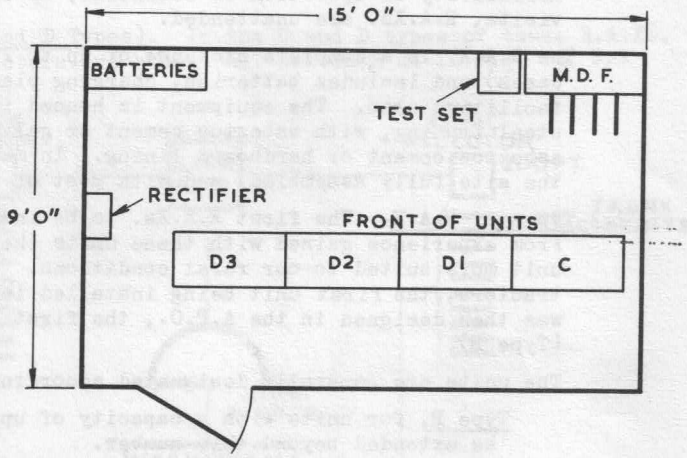
The Type B exchanges were originally installed in huts of 9' x 9' but the larger huts are now used as many Type B units, (50 lines), are eventually replaced with Type C units, (50-200 lines). No separate M.D.F. is required with the Type B, as this is mounted within the unit itself.

Fig. 4 shows the interior of an R.A.X. which contains a C unit and two D units, the C unit being adjacent to the end wall.

2.5 Use of Line Finders. Line finders are suitable for R.A.Xs. because the subscriber calling rate is generally low. In most cases less than 200 lines are connected, and therefore the standard 200 point line finder is unnecessarily large. A 50 point uniselector is generally used as a line finder, although the 100 point bimotional switch was used in some units of earlier design. Wherever possible the uniselector is used because of its reliability and comparative cheapness.



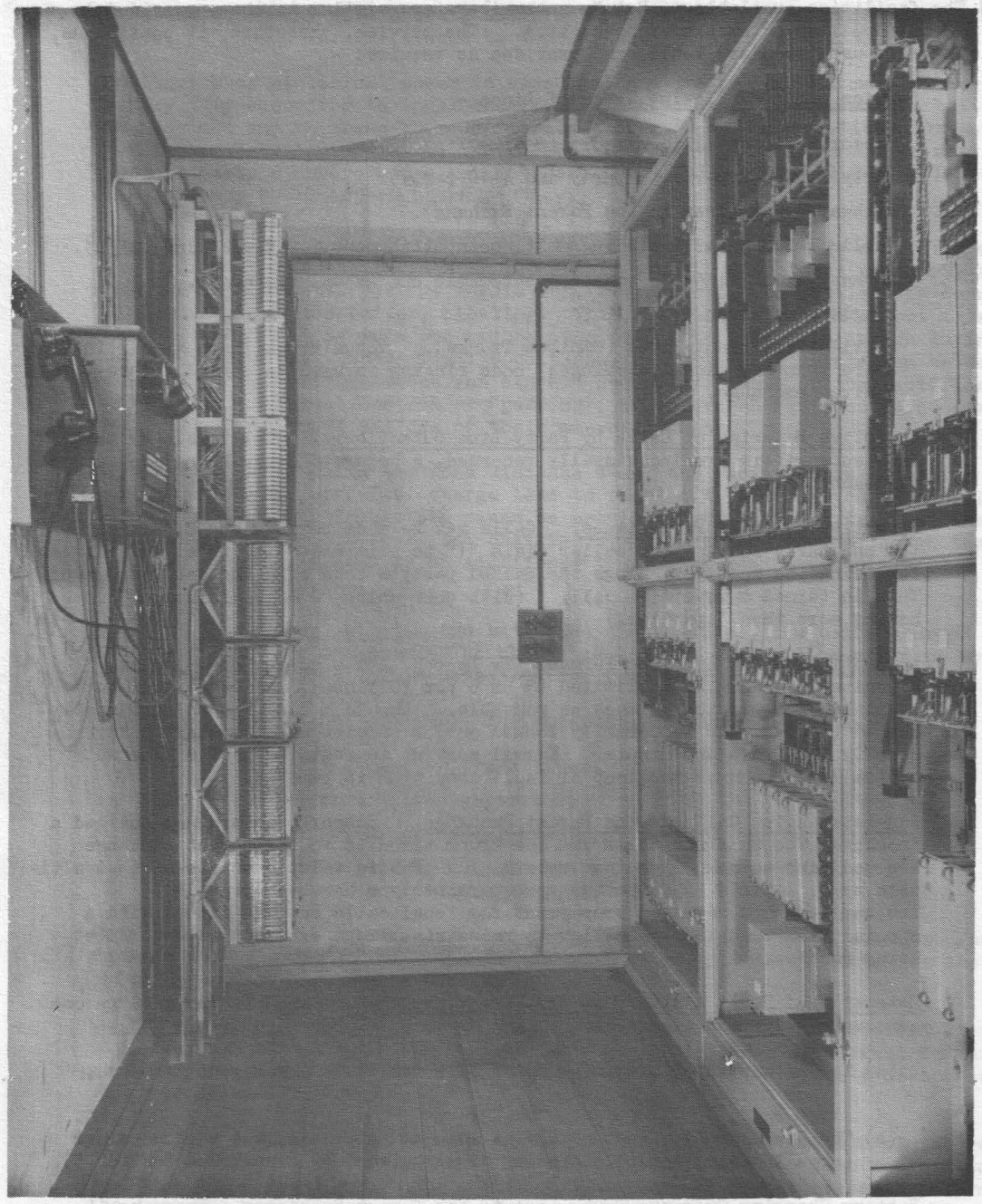
(a)



(b)

TYPICAL EQUIPMENT LAYOUTS
50/200 LINE R.A.X.

FIG. 3.



Test Set. M.D.F. C Unit. D1 Unit. Part of D2 Unit.

TYPE 'C' R.A.X.

FIG. 4.

3. R.A.X. - FACILITIES AVAILABLE.

3.1 The facilities available to R.A.X. subscribers are similar to those provided in a metropolitan automatic exchange area. The service, therefore, is continuous, secret, uses standard tones, and provides as required -

Service on the Following Types of Lines -

Subscriber's metallic circuit (2 wire lines).

Party lines (2 party, 3 party and 4-10 party).

Bothway trunk lines to the Parent Exchange.

Public Telephones (including multi-coin attachment for trunk line calls).

Bothway trunk lines to adjacent automatic and manual exchanges.

Single wire lines.

Multi-office trunk lines (Omnibus Trunks). These trunk lines appear in more than one manual exchange; code ringing is used to signal the required exchange.

Selective Metering of Calls by Party Line Subscribers. Calls made by party line subscribers are individually recorded, a separate meter being provided for each party.

Revertive Calls on Party Lines. Calls may be made between any 2 parties of the one party line. The caller dials "1" to eliminate dial tone, and without replacing the receiver, rings the called party's code with the hand generator. This is termed a revertive call. (With some units "01" is dialled on lines having more than 3 parties.)

Automatic Lockout of Lines Permanently Looped. The number of switching circuits in an R.A.X. is limited (5 or 6 per 50 lines), and these must be available for service as much as possible. Should a line become permanently looped (P.G.) it is temporarily locked out of service after a short delay - usually less than one minute. Normal service is restored to the line automatically as soon as the loop or fault condition is removed.

Non-metering on Calls to the Parent Exchange. Subscribers are not charged a 'booking' fee on trunk calls and the trunk circuits to the parent exchange are modified to make them 'non-metering'. Public telephones are of the multi-coin type. Since 1958 the new post payment type has been provided. The earlier type required prepayment for local calls but was fitted with a special dial enabling the caller to raise the parent exchange without first using pennies.

Detection of Fault Alarms from the Parent Exchange. This is provided in one of several ways, such as -

(a) The extension of alarms by means of a 'call' to the Parent Exchange,

and/or,

(b) The dialling of a test number at regular intervals, the various alarm (or all clear) conditions being distinguished by tones (See Section 5).

Battery Charging Over the Trunk Line to the Parent Exchange. Where no commercial power is available at the R.A.X. this alternative may be used. Several circuit arrangements are in use and these are discussed in Section 7.

Testing Facilities. Types C and D units are equipped with a test set which permits subscriber's line testing and also routine tests of selectors. Some early units provided for testing of subscribers' lines from the parent exchange (See Section 9.2). Type B units are provided with a simple test set in some States but not in others.

4. STANDARD A.P.O. TYPE R.A.Xs.

4.1 The two standard Types B and C have many features in common. They each use the same subscriber's line circuit, 2 party 2/3 party and 4/10 party relay sets, public telephone, and charge-over-trunk relay sets. The fully imported C Types use the same ringing code interrupter as the B Types. The B Type differs in that no bimotional switches are used. In each case all uniselectors are A.P.O. or the similar B.P.O. Type.

4.2 Elimination of Allotters. Experience with earlier units has shown that common equipment is a source of serious trouble, as its failure may put the R.A.X. "off the air". As R.A.Xs. are normally unattended, considerable time may elapse before the Technician arrives to restore service.
For this reason allotters have been eliminated from the line finder circuits of these standard R.A.Xs. The multiple search system is used; that is, all free line finders hunt in unison for a calling line, the first switch to reach the line is accepted, and the others release to be available for other calls.

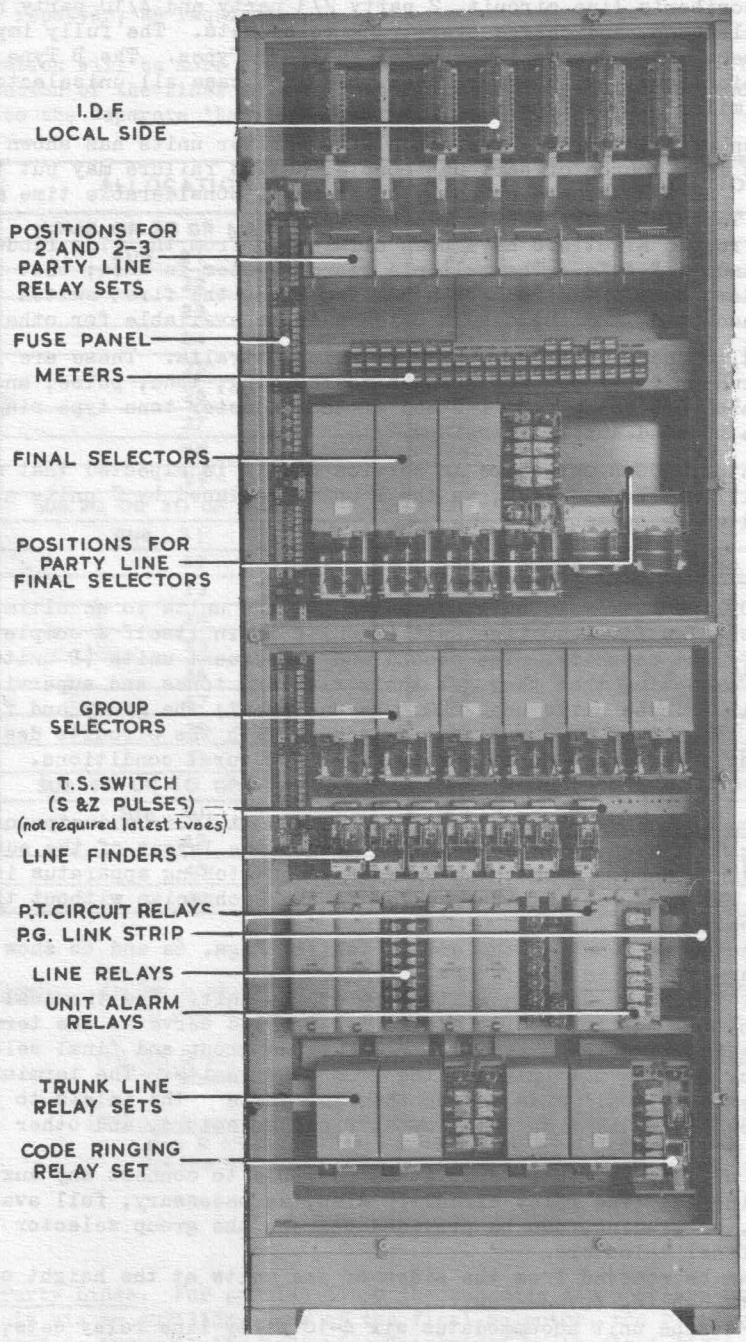
4.3 Since 1954, C and D units have been made in Australia. These are identical to the British units except for changes to the ring, tone, pulse, and alarm circuits, which use relay sets instead of the inductor tone type ringing machine and plate mounted auxiliary relays.

Approximately 500 B units are in service and it is expected that more than this number will not be required, as the B units replaced by C units are being reinstalled where suitable.

5. A.P.O. 50/200 LINE R.A.X. (TYPE C-D).

5.1 The 50/200 line R.A.X. is built up using 50 line units to an ultimate capacity of 200 lines. The first 50 line unit (C unit) is in itself a complete telephone exchange of that capacity. The second and subsequent units (D units) are similar, with the exception that they get their ringing, tones and supervisory pulses from the C unit. These units use 2000 type equipment; the group and final selectors are 2000 type or SE.50 bimotional switches, with the circuits designed to perform the slightly different functions required for rural conditions.

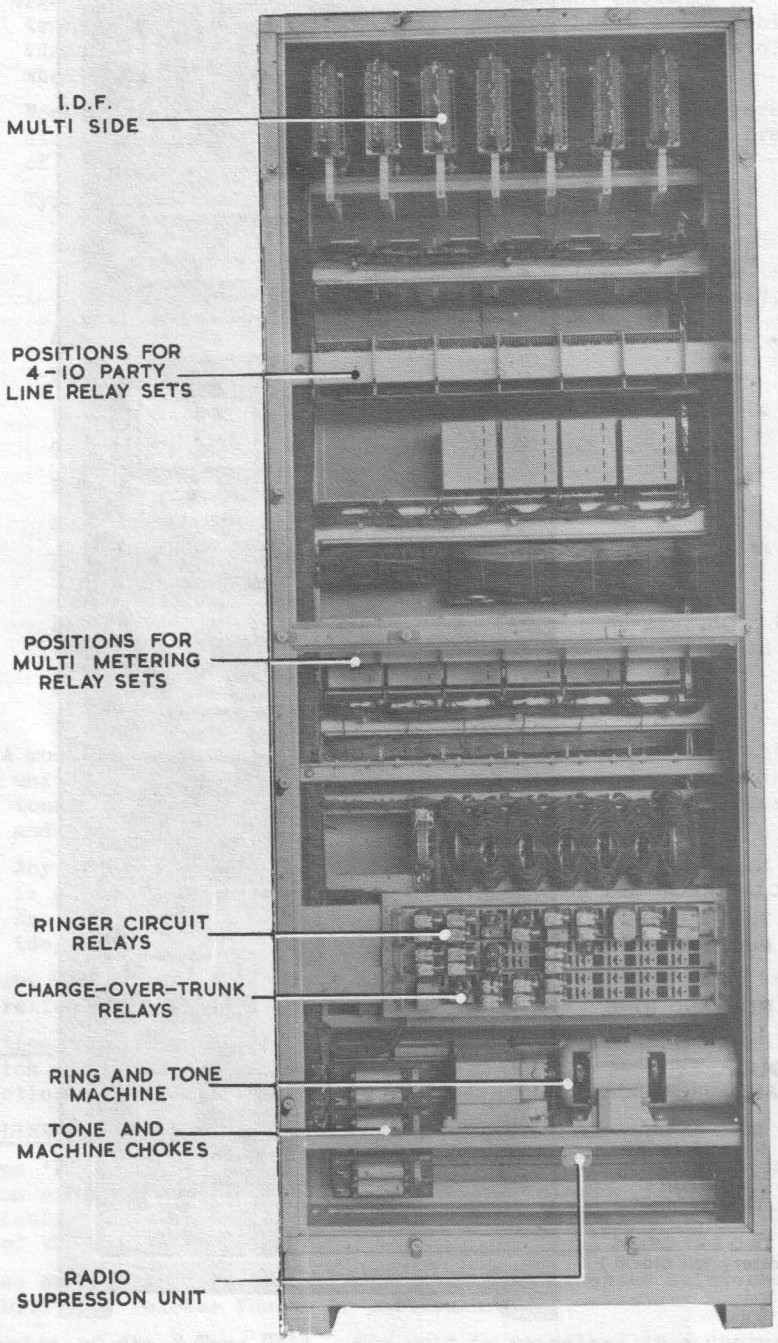
5.2 Description of the Type C and D Units. Each unit is in a dustproof steel cabinet measuring 8'3" high, 3' wide and 1'8" deep. The layout of the equipment facilitates maintenance, in that the bulk of the switching apparatus is mounted on the front of the unit, and can be handled by the Technician without the aid of stools or ladders.
Fig. 5 shows the front of the unit, whilst Figs. 6a and 6b show the rear of the two different C units now in use.
The local I.D.F. is mounted at the top of the unit. The terminal blocks at the rear form the 'multiple' side of the I.D.F., and serve as the terminating point for the incoming lines from the M.D.F., the group and final selector bank multiples, and the multiple cabling from other units. The terminal blocks at the front are the 'local' side and on them terminate the inlets to the subscriber's line circuits, trunk line relay sets, final selectors, and other auxiliary relay sets.
By means of jumpers, therefore, it is possible to connect any auxiliary apparatus to any line and line relay circuit. Also, as necessary, full availability connections, or grading, can be provided between the group selector bank multiples and the final selectors.
Plates can be removed from the sides of the units at the height of the I.D.F. to facilitate cabling between units.
The rear of the unit accommodates six 4-10 party line relay sets, if required; also cradles are provided for multi-metering relay sets. The ringing machine, when provided is mounted at the bottom of the rear side; the associated relays plus the charge-over-trunk circuit components, are plate mounted above the machine. Where ring & tone and pulse relay sets are used instead of the ringing machine, these are located in approximately the same position.
Type D units have a similar layout to the C units, except for the omission of the ring and tone equipment and associated common services.



A.P.O. TYPE 'C' R.A.X. UNIT FRONT VIEW.
(BRITISH MADE).

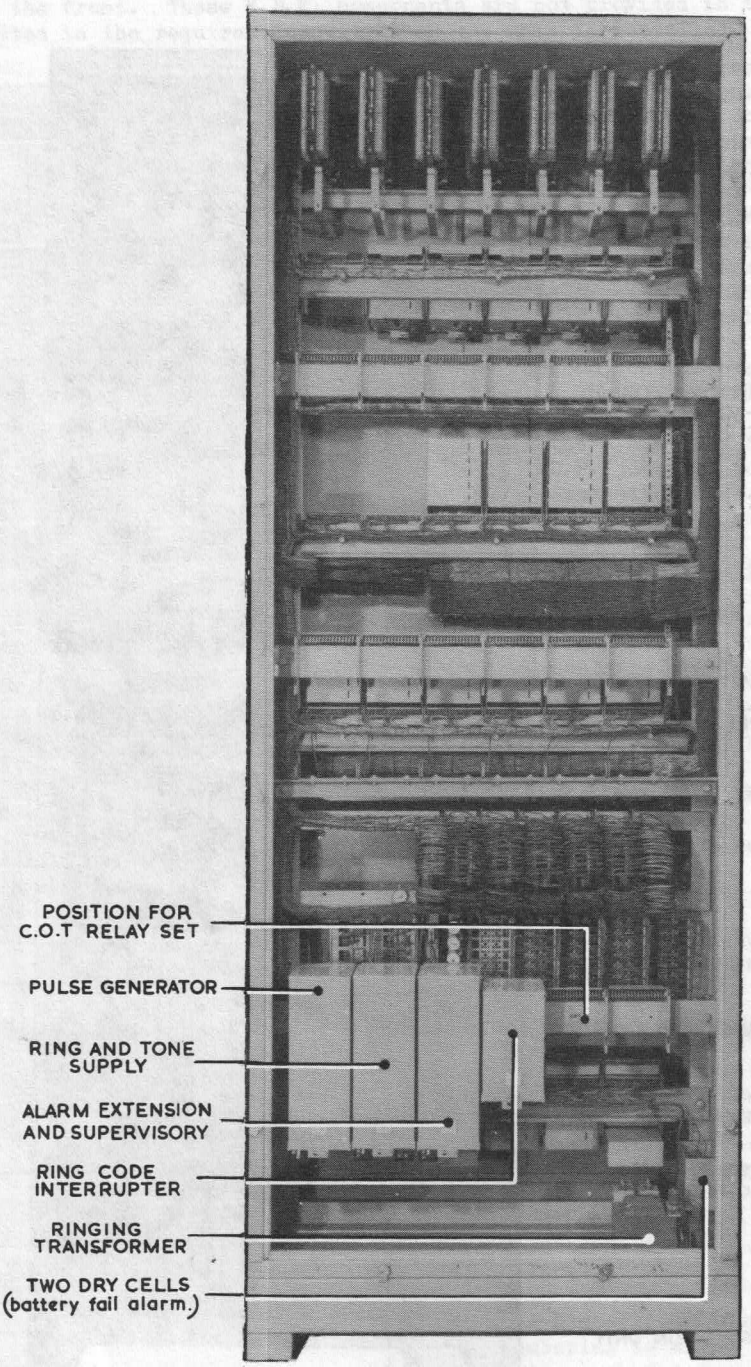
FIG. 5.

The extent to which equipment provision and location have been altered in the later unit, may be seen from a comparison of Figs. 6a and 6b.



A.P.O. TYPE 'C' R.A.X. UNIT (REAR).
(BRITISH MADE).

FIG. 6a.



A.P.O. TYPE 'C' R.A.X. UNIT (REAR).
(AUSTRALIAN MADE).

FIG. 6b.

5.3 Equipment Provision. Each C unit is equipped fully with group selectors and regular final selectors, but trunk line relay sets, auxiliary relay sets, and party line equipment are added as required. Type D units are supplied with 3 group selectors and 3 regular final selectors. Each fully equipped unit would contain the following equipment -

(i) British and Australian C or D units -

45 Subscribers' line circuits (plate mounted).
5 Bothway trunk line relay sets (auto-manual or auto-auto).
6 Line Finders) comprising 6 link circuits.
6 Group Selectors)
4 Regular final selectors (12 maximum for 200 line R.A.X. with 3 D units).

2 Party line final selectors.
6 2 or 2-3 party line relay sets.
6 4-10 party line relay sets.
1 Public telephone auxiliary line circuit (plate mounted).
1 Set of unit alarm relays (plate mounted).

(ii) Common and auxiliary equipment, C units only -

British	Australian
1 charge over trunk circuit (plate mounted).	1 charge over trunk relay set.
1 code ringing relay set.	1 ring code interrupter relay set.
1 ring and tone machine with associated ring, tone and alarm circuit (plate mounted).	1 pulse generating relay set.
	1 ring and tone supply relay set.
	1 alarm extension and supervisory relay set.

When relay sets are used ring current and dial tone are produced by vibrating relays; N.U., busy and ring tone by valve oscillators; ring and tones are interrupted by pulsing relays. (See Section 9.1.).

The charge over trunk facility (when used) and the extension of alarms, are associated (by means of jumpers) with the first and second trunk lines of the C unit only.

5.4 Numbering Scheme. Fig. 7 is the trunking diagram of an A.P.O. Type 'C' R.A.X.

A 3 figure numbering scheme is used, levels 2, 3 and 4 of the 100 outlet group selectors being used for subscribers' services.

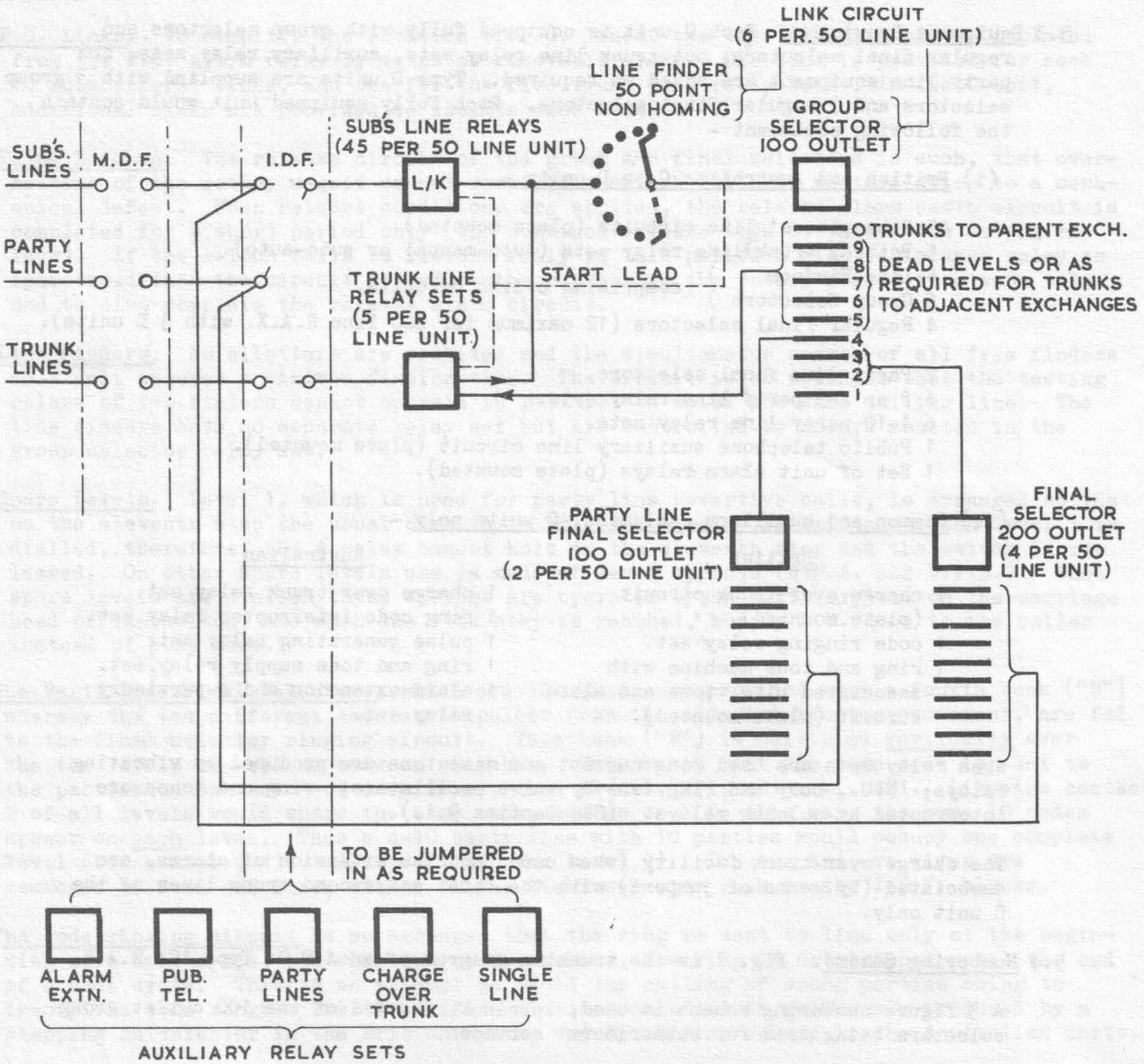
Exclusive subscribers, including public telephone and 2 party lines, are in the series 200-399, being served by the 200 line regular final selectors trunked from levels 2 and 3.

2-3 and 4-10 party lines are generally included in the 400-499 series, being served by the party line final selectors trunked from level 4, except when more than 200 lines are connected, in which case another level is used.

The parent exchange is trunked from level 0 of the group selector, whilst levels 5-9 can be used for adjacent R.A.Xs. and manual exchanges.

Level 1 of the group selectors is used for releasing the link circuit on revertive party line calls.

5.5 General Operation - Local Calls. The caller lifts the handset, the line circuit marks the calling line on the line finder banks and applies a start signal to all free line finders in the unit. The first line finder to reach the line extends it to the associated group selector. The remaining line finders come to rest and are available for further calls. Dial tone is returned to the caller from the group selector.



TRUNKING DIAGRAM 50/200 LINE A.P.O. TYPE 'C' R.A.X.

FIG. 7.

The caller dials three digits in the series 200-499. The first digit steps the carriage of the group selector to the level dialled and the wipers hunt automatically for a free outlet to a regular final selector (initial digit 2 or 3), or to a party line final selector (initial digit 4). The first free outlet is seized and the connection is extended to the final selector.

The last 2 digits are dialled - the final selector (regular or party line) functions in the usual manner except that the party line selector causes the appropriate code ring to be connected to the line, instead of the normal auto-ring.

At the end of the call, the connection is released by the calling subscriber replacing the handset. If the caller fails to clear after the called subscriber has done so, a "Called Subscriber Held" alarm is given after a short delay.

Permanent loops are forcibly released from the link circuits and a P.G. alarm given.

Trunk or Junction Calls.

Outgoing calls to the parent exchange use level 0 on the group selectors, and calls to adjacent exchanges use levels 5 to 9, the outlets being trunked via bothway repeater relay sets (auto-manual or auto-auto).
Overflow meters are connected to all working levels of the group selectors.

Incoming calls from the parent or adjacent exchanges loop the line relay circuit in these same trunk or junction line relay sets, and cause the free line finders to search for the calling line in the manner described for a local call.

Party Line Calls. A special telephone with a hand generator is used for party line subscribers.

2 Party Line. Selective ringing is provided from the regular final selector via an auxiliary line circuit. The ring is earth circuit return on either the A or B leg. On outgoing calls a separate meter is selected by the auxiliary circuit, depending on the party calling. Calls between parties are made by the caller dialling "1" and then using the hand generator. The group selector steps to the first level, drives to the eleventh step and then releases. This causes the line circuit to revert to the P.G. condition; the line finder and group selector are thus freed.

2-3 Party Line. The auxiliary relay set selects the required meter on outgoing calls. On incoming calls the appropriate code ring is connected by the party line final selector. Inter-party calls are made in the same way as for the 2 party line.

4-10 Party Line. A more elaborate auxiliary circuit is necessary for this class of line and the telephones are fitted with a special dial. Outgoing calls are always prefixed by the digit "0". The dialling circuit of the telephone transmits impulses (earth circuit return) over both legs of the line, the dial being arranged so that one impulse of the train is 'masked' from the A leg. (A different impulse for each party.) Two uniselectors in the auxiliary relay set respond to this initial train of impulses (one to the A leg pulses and one to the B), and ensure respectively that - (a) the calling party's meter is switched into circuit, and (b) no call can proceed unless prefixed by "0". Code ring is connected to the line by the party line final selector.

Inter-party calls are made as is done on the 2 and 2-3 party circuits, except that with the early units the caller must dial "01".

5.6 Special Circuit Features A.P.O. Type C-D R.A.X.

In general, the switching circuits follow conventional 2000 type practice. Several extra features have been included to suit the special requirements of R.A.Xs.

Metering. No positive battery is provided; metering is by a negative battery pulse over a fourth wire (M) in each trunk between the line circuit and final selector (via the line finder and group selector).

Outlet Testing, Group Selectors. The free trunk condition for which the group selector searches is battery on the P wire. As the group selector cannot test into a P wire which is open circuit or at earth potential, "stop on busy" troubles are virtually eliminated.

Forced Release, Group Selectors. If a group selector is looped and dialling is not started within a short time, two pulses known as the S and Z pulses cause the group selector to open the incoming P wire. This causes the release of the L relay in the line circuit and the setting up of the P.G. fault condition. The K relay holds to the line loop (or fault). (It is worth noting here that the subscriber's line circuit is so designed that during a normal call, both L and K relays are held operated.)

P.G. Links. To simplify the location of P.G. lines, the line circuits can be isolated from the P.G. alarm relay by means of removable links. One link is provided for each 10 subscribers' lines, and one for the five trunk line relay sets. In the C unit, additional links are provided to isolate each D unit.

Pulse Release. The release circuit of the group and final selectors is such, that overheating of the rotary magnet cannot occur if a switch fails to restore owing to a mechanical defect. When release conditions are applied, the release alarm earth circuit is completed for a short period only (the combined release lags of three slow acting relays). If the switch fails to restore fully in this period a high resistance relay is introduced into the circuit to reduce the current in the rotary magnet to a safe value, and to also complete the release alarm circuit.

Line Finders. No allotters are provided and the simultaneous search of all free finders in a unit ensures a minimum finding time. The circuit is so arranged that the testing relays of two finders cannot operate in parallel to seize the same calling line. The line finders have no separate relay set but are controlled by relays mounted in the group selector relay set.

Spare Levels. Level 1, which is used for party line revertive calls, is arranged so that on the eleventh step the usual circuit to hold the A relay is omitted. When level 1 is dialled, therefore, the A relay cannot hold to the eleventh step and the switch is released. On other spare levels use is made of level springs (N.P.A. and N.P.B.). When spare levels are dialled these springs are operated by an auxiliary cam on the carriage head of the switch, and when the 11th step is reached, supply N.U. tone to the caller instead of busy tone.

The Party Line Final Selectors, which are 100 line, are provided with a fourth bank ("R") whereby the ten different code earth pulses from the code interrupter equipment, are fed to the final selector ringing circuit. This bank ("R") is multipled vertically over the ten levels as well as between switches. This means that the same code is sent to the parties on contact 1 of each level, that is 411, 421, 431 ..... 401. Likewise contact 2 of all levels would share the same code, and so on. In this way, the same 10 codes appear on each level. Thus a 4-10 party line with 10 parties would occupy one complete level (for example, 431, 432 ..... 430 for level 3). The +ve and -ve wires are commoned to form one line, either on the final selector bank or the I.D.F. blocks.

The code ringing circuit is so arranged that the ring is sent to line only at the beginning of a code cycle, and when the party answers, the ring is not tripped until the end of a code cycle. This is an attempt to avoid the calling of wrong parties owing to incomplete code rings. The ten different sequences of earth pulses are produced by a stepping uniselector in the British units, and by pulsing relays in the Australian units.

The public telephone auxiliary line circuit is designed so that when the parent exchange is called, the operator receives 12-15 seconds of ring tone on answering the call, to indicate that the call is from a public telephone.

Fault Alarms. The alarms provided, and the methods used to signal the parent exchange and to identify the type of fault, have undergone some alteration since the first A.P.O. 'C' units were installed. The fault alarms provided may be summarised as follows -

	URGENT.	NON-URGENT.
Early units	Fuse alarm Release alarm C.S.H. alarm	P.G.
Additional alarms later units (Australian manufacture).	Ring and tone fail Power fail Battery fail	N.U. alarm (ceased and unallotted lines).

Provision is made for noting and identifying alarms in one of the following ways -

(i) Urgent alarms are so arranged that the parent exchange is 'called' on a trunk line. The telephonist on answering hears a tone which serves to identify the type of alarm. The trunk line circuit restores to normal when the plug is withdrawn.

Non-urgent and urgent alarms may be detected from the parent exchange by dialling a special test number (for example, 399), the presence or absence of any alarm being notified by a distinguishing tone.

Typical tones used are -

Condition	Early units (using ringing machine).	Later units (using ring & tone relay sets).
All Clear	Inverted ring tone	– – – – –
Fuse Alarm	Busy tone	– – ———
Release Alarm	Dial tone	– ——— –
C.S.H. Alarm	Continuous 400 c/s tone	– ———
P.G. Alarm	N.U. tone	– – –
N.U. Alarm	.....	– –
Power fail Alarm	.....	——— –
Battery Fail (or low voltage)	.....	Buzzertone. (From self interrupted relay).
Ring and Tone Fail	.....	No tone.

Ring tone pulses

(ii) A modification of the above arrangement is often used on both types of C unit, as the telephonists at the parent exchange may dismiss the service tone as unimportant, particularly as the line is found clear if unplugged and answered a second time.

Any urgent alarm is extended as before, but the tone heard in every case is a single distinctive tone (6 or 5 pips of 400 c/s tone, repeated). The Technician is advised, and on dialling the test number hears the identifying tone as listed above under 'Early units'.

The test number may be dialled at any time and a routine check is perhaps the most reliable method of all.

Congestion meters are provided, and one is pulse operated at regular intervals if all link circuits in a unit become busy together. The approximate duration of congestion is thus recorded.

6. A.P.O. 40 LINE R.A.X. (TYPE B).

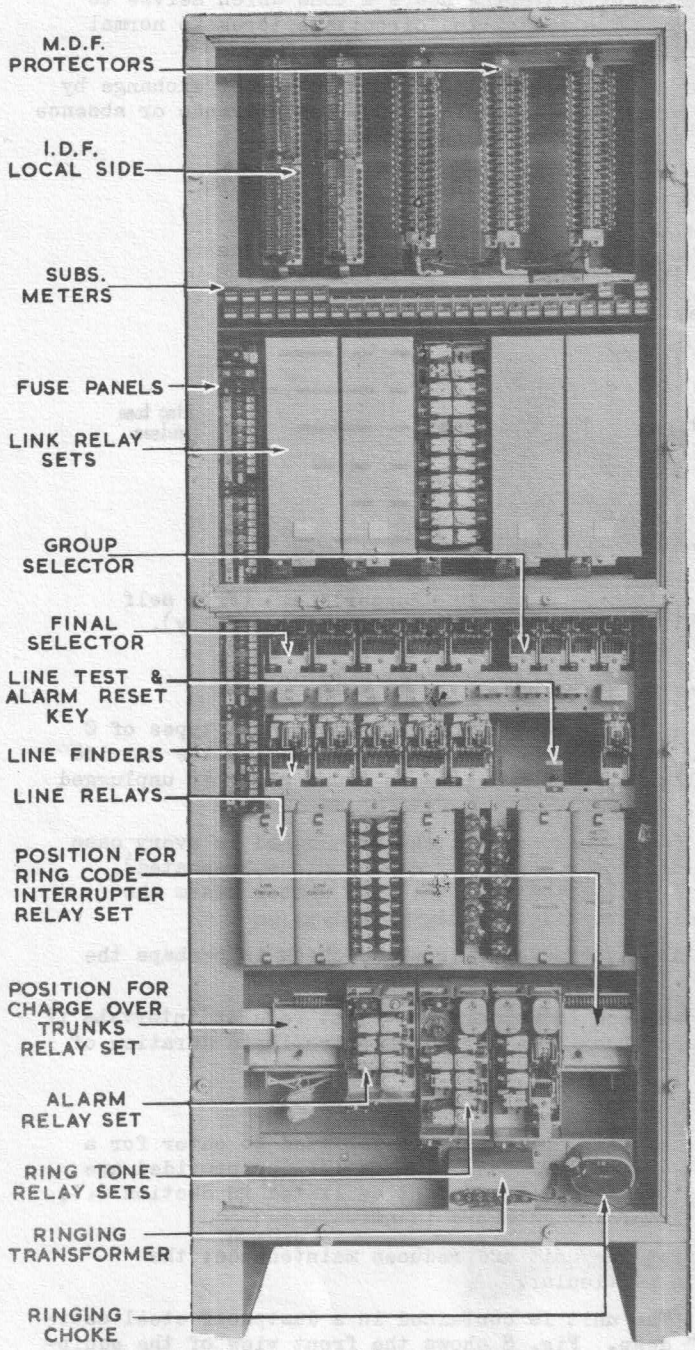
6.1 The type 'B' R.A.X. is a small non-extendable exchange designed to cater for a maximum of 40 subscribers and five trunk lines. The facilities provided are practically the same as for the Type C units, in fact as listed in Section 4.1, many of the auxiliary circuits and relay sets are identical.

The use of uniselectors simplifies the unit and reduces maintenance; the possibility of release faults in particular.

6.2 Description of the B Type Unit. The unit is contained in a dustproof steel cabinet 7' high, 2'7" wide and 1'8" deep. Fig. 8 shows the front view of the equipment.

Layout of Equipment. As will be seen, most of the equipment is fitted on the front of the unit, the rear being used for party line relay sets. Space is also provided at the rear for the addition of multi-metering relay sets.

Main Distributing Frame. At the top of the unit is the M.D.F. which has an ultimate capacity of 75 fuses (3 blocks), mounted on the rear, and 60 protectors (3 strips) mounted on the front. These M.D.F. components are not provided in the unit initially but are fitted in the required quantity when the unit is installed.



A.P.O. TYPE 'B' R.A.X. UNIT (FRONT).

FIG. 8.

Local I.D.F. The local I.D.F. is also at the top of the unit. Two terminal blocks at the rear form the 'multiple' side and serve as the terminating point for the final selector multiple, the M.D.F. cabling and the group selector multiple. Four terminal blocks on the front form the 'local' side and on them terminate the inlets to the trunk and subscribers' line circuits, and the cabling from the auxiliary circuits - party line, public telephone, charge-over-trunk, and fault test number. The I.D.F., therefore, provides flexibility of connections so that the R.A.X. may be varied, by means of I.D.F. jumpers, to accommodate as many exclusive lines, trunk lines and auxiliary circuits as required.

6.3 Equipment Provision. When installed, the unit is equipped with only sufficient relay sets to provide the required service. Fully equipped, the unit contains the following apparatus -

40 Subscriber's line circuits.
5 Party line relay sets (maximum 4/10 circuits is two).
5 Link circuits. (Each circuit consists of - a line finder, group selector, final selector, and link relay set.)
5 Trunk line circuits (plate mounted).
1 Public telephone auxiliary circuit.
1 Charge over trunk relay set.
1 Alarm relay set.
1 Code ring interrupter relay set.
1 Ring, tone and pulse circuit. (2 relay sets using vibratory relays for ring, ring tone and dial tone; valve oscillator for busy and N.U. tones; stepping uniselector to interrupt ring and tones.)

NOTE: Ten is the maximum number of parties on 2/3 and/or 4/10 party lines.

6.4 Numbering Scheme. Two digit numbering is used, the subscribers being numbered from 20-59. Exclusive services and 2-party lines normally occupy the 20-49 group while 2-3 and 4/10 party lines are placed in the 50-59 group (exclusive services may use this group when not required for party lines).

The maximum of 5 trunk lines may be in one, two, or three groups, but trunks to any one exchange (parent or adjacent) would very rarely exceed 2. The parent exchange is raised by dialling "01", any further lines in this group being numbered 02, 03 and so on as required. Automatic hunting over all the busy trunks in the group is provided.

Adjacent manual or automatic exchanges may be included in the switching scheme, and adjacent automatic exchanges are usually in group 9 and raised by dialling "91". A second trunk in the group (92) would be selected by automatic search if 91 were busy.

An adjacent manual exchange would normally be selected by dialling "04".

As will be seen from the above the trunk switching possibilities are quite flexible up to the total of 5 trunks or junctions.

6.5 General Operation. Fig. 9 is the trunking diagram of the A.P.O. type 'B' R.A.X.

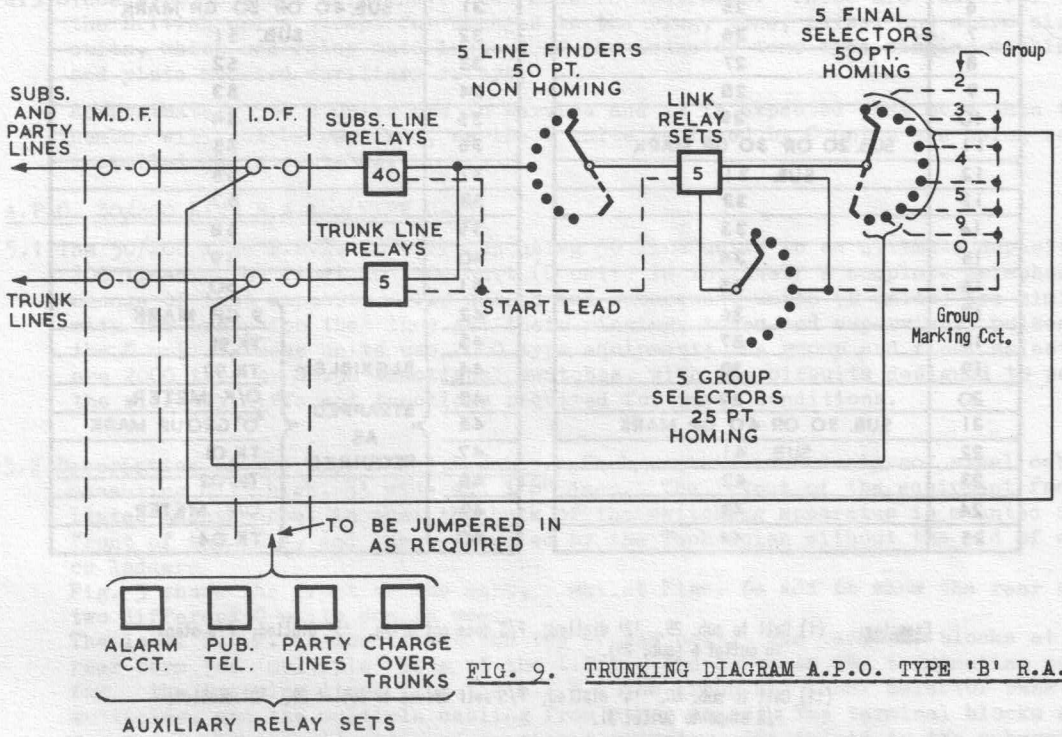


FIG. 9. TRUNKING DIAGRAM A.P.O. TYPE 'B' R.A.X.

Each link circuit includes a line finder, a group selector and a final selector.

The group selector is unlike the usual group selector in that, it has no +, - and P wipers and the speaking circuit by-passes it altogether. Its principal function is group marking of the final selector bank.

Local Call. The calling subscriber is switched to the link circuit by the first free line finder to test into the calling line. Dial tone is returned to the caller. The first digit (2, 3, 4 or 5) is dialled, and the group selector steps under the control of the impulses received. This results in one of the final selector banks being 'marked' one contact before the beginning of the group dialled; the final selector then self drives to this marked contact. The second digit is dialled and the final selector steps to the wanted line under the control of these impulses. At this stage the link circuit performs the normal final selector functions (testing, ringing, metering, etc.).

Trunk or junction calls are set up in a similar manner; when '0' or '9' is the first digit dialled, the link circuit is changed to function as an auto-manual, or auto-auto repeater, as required.

This operation will be more readily understood by reference to Fig. 10 which shows the allocation of the final selector outlets, and the relation of the group marking contacts to the separate 'tens' groups.

F/S OUTLET	ALLOCATION
1	HOME OR 20 GP. MARK.
2	SUB. 21
3	22
4	23
5	24
6	25
7	26
8	27
9	28
10	29
11	SUB. 20 OR 30 GP. MARK
12	SUB. 31
13	32
14	33
15	34
16	35
17	36
18	37
19	38
20	39
21	SUB. 30 OR 40 GP. MARK
22	SUB. 41
23	42
24	43
25	44

F/S OUTLET	ALLOCATION	
26	SUB. 45	
27	46	
28	47	
29	48	
30	49	
31	SUB. 40 OR 50 GP. MARK	
32	SUB. 51	
33	52	
34	53	
35	54	
36	55	
37	56	
38	57	
39	58	
40	59	
41	50	
42	FLEXIBLE. STRAPPED AS REQUIRED	9 GP. MARK
43		TK.91
44		TK.92
45		O/F METER.
46		"0" GROUP MARK
47		TK.01
48		TK.02
49		O/F METER
50		TK.04

Examples: (i) Call to sub. 25. '2' dialled; F/S does not drive. '5' dialled; F/S steps to outlet 6 (sub. 25).

(ii) Call to sub. 40. '4' dialled; F/S self drives to outlet 21. '0' dialled; F/S steps to outlet 31.

(iii) Call to parent exchange. '0' dialled; F/S drives to 46. '1' dialled; F/S steps to outlet 47. If 1st line busy F/S self drives to outlet 48 (02). If 2nd line also busy F/S drives to outlet 49 - overflow meter operated.

FIG. 10.

Calls to Party Lines. For parties 51-50 the ten code earth pulses are fed to the link circuit via an auxiliary bank of the final selector, the ringing circuit being altered to transmit the code ring determined by the last digit dialled.

Auxiliary circuits for party line, public telephone, charge-over-trunk, ring code interrupter, lockout of P.G. lines, P.G. isolating links, and fault test number function in a similar way to those in the C units. Provision is not normally made for extension of alarms to the parent exchange, but a circuit to enable this is sometimes added.

7. POWER SUPPLY FOR R.A.Xs.

7.1 While the equipment will operate satisfactorily between potentials of 46 and 60 volts, it should for preference be kept within fairly narrow limits.

Continuity of electrical power is essential and the methods of maintaining the supply vary according to local conditions. In all cases at least one battery is provided and in areas where commercial power is either unreliable or unavailable, 2 batteries may be installed. The consumption of a B type unit is approximately 6 ampere hours per day, and for a fully equipped C plus D installation, it may be 20 ampere hours per day.

7.2 When the local power is A.C., one enclosed type battery is used; generally eight 6 volt batteries of approximately 100 ampere hours. A constant potential rectifier having automatic voltage regulation ("Transrector" or similar) is connected to the unit with the battery floating. This unit increases its output to a maximum for heavy load periods and reduces the output to a trickle charge during periods of no load. Under ideal conditions the battery is maintained between 51.6 and 55.2 V, and refresher charges are not necessary. Many of the rectifiers may be switched to manual control or "gassing", if an overcharge becomes necessary following a prolonged failure of the commercial supply.

If the A.C. power mains are some distance away, the rectifier is sometimes mounted on a pole and a 2 wire D.C. charge lead to the R.A.X. provided on an aerial route. The charge lead may in certain cases be provided between the R.A.X. and the parent exchange. This is distinct from charging over the trunk line, although the charge lead may be readily used as an additional trunk line when commercial power becomes available at the R.A.X.

7.3 When the local power is D.C., two batteries are provided, one being charged while the other supplies the load. The charge is limited to the correct value by means of series resistances. This method is now very rarely used.

7.4 When local power is not available the alternatives which may be used are -

Charging over trunk lines.

A wind driven generator.

A petrol or diesel electric generator set.

Transporting charged batteries from a station having a commercial power supply.

Each method has its disadvantages so that the method adopted in a particular case depends on the existing conditions. In some cases, 2 sets of batteries are provided (or a larger capacity battery).

Charging Over a Trunk Line. With this method, a rectifier is provided at the parent exchange, and with the 'charge' key operated, charging current is automatically connected when the line is not in use, and automatically disconnected if it is seized from either end.

The voltage drop in the line is appreciable, so the output voltage of the rectifier is determined by the charging current required, and the line resistance. Voltages up to 150 V are used. Usually the charge is connected earth return with the two line wires in parallel. Serious electrolysis of underground cables can occur if a sufficiently low resistance earth is not obtained. For this reason a metallic circuit charge over the trunk is sometimes used. With a busy R.A.X. the charging time on the trunk may be insufficient to maintain the battery in a charged state. To overcome this, a modification of the scheme is sometimes used (mainly in N.S.W.) whereby the charge is not interrupted by calls on the trunk. A cailho circuit carries the charging current, while dialling into the R.A.X. is done by means of low frequenty A.C. impulses (100 c/s).

Wind Driven Generator. A three bladed variable pitch propellor geared to a D.C. generator, is mounted on a steel mast adjacent to the R.A.X. (see Fig. 11.) Many of these are in use where wind conditions are suitable (particularly in S.A. and Victoria).

The generator must produce a suitable charging current under varying wind conditions; therefore to avoid excessive output, its speed of rotation must be controlled during high winds. This control is by a governor attached to the shaft, which, according to the wind velocity, varies the angle (pitch) that the blades offer to the wind. The variation is such that no increase of propellor speeds (or output) occurs with winds over 20 m.p.h. The output of the generator can be varied by changing the position of the tail in relation to the blades; a hand lever allows this to be done and also can be used to stop the propellor.

A rectifier in series with the charge lead prevents a reverse current when the generator voltage falls below that of the battery. Originally a cut-out relay was used for this purpose.

Two batteries are connected in parallel to give a greater reserve during periods of little or no wind.

TYPICAL WIND DRIVEN GENERATOR INSTALLATION.

FIG. 11.

Motor Generator Sets. Development of reliable methods of automatic or remote control, has now made this method preferable in many cases, to charging over the trunk or the use of wind driven generators.

The petrol or diesel electric set is mounted on a concrete base a short distance from the R.A.X. building and protected by a well ventilated but weatherproof housing. A 2-3 H.P. four stroke engine, water cooled by means of a tank and with fuel capacity sufficient for a total running time of about 24 hours is generally used. The engine may be started and stopped from a control panel in the R.A.X., or by dialling a special number from the parent exchange and then operating "start" or "stop" keys in the control circuit. In the latter case supervision is by means of tones to determine whether the motor has started (or stopped), and the generator is charging.

Automatic start and stop, under control of the battery voltage or ampere-hour discharge, has been successfully tried. The remote control method, however, is more widely used.

The generator has an additional field winding (series) and is used as a motor operating from the battery in order to start the engine. Cranking ceases if the engine does not run in a reasonable time.

Transporting charged batteries from a station having a commercial power supply is a costly and cumbersome method, and is now rarely used except perhaps as a temporary expedient.

8. EARLY TYPES OF R.A.X.

8.1 The R.A.Xs. installed in Australia before the introduction of the standard A.P.O. units were supplied by the following -

Automatic Electric Co. (A.E.C.)

British General Electric Co. (G.E.C.)

Messrs. Siemens Bros. and Co.

Standard Telephones and Cables Pty. Ltd. (S.T.C.)

The methods used by these firms, to provide the various R.A.X. facilities, differed from each other in many respects, including the circuit arrangements and the items of equipment used to perform the various functions. No further purchases of these types will be made.

8.2 A.E.C. Type R.A.X. The trunking of the A.E.C. Unit is in Fig. 12. Uniselectors (50 point) are used as line finders. In B types, 100 point final selectors are used, but in C and D types (to avoid the use of group selectors) 200 point final selectors are used. The allotter is called the assigner in these types. The number of connecting circuits is usually 5 or 6 per 50 lines.

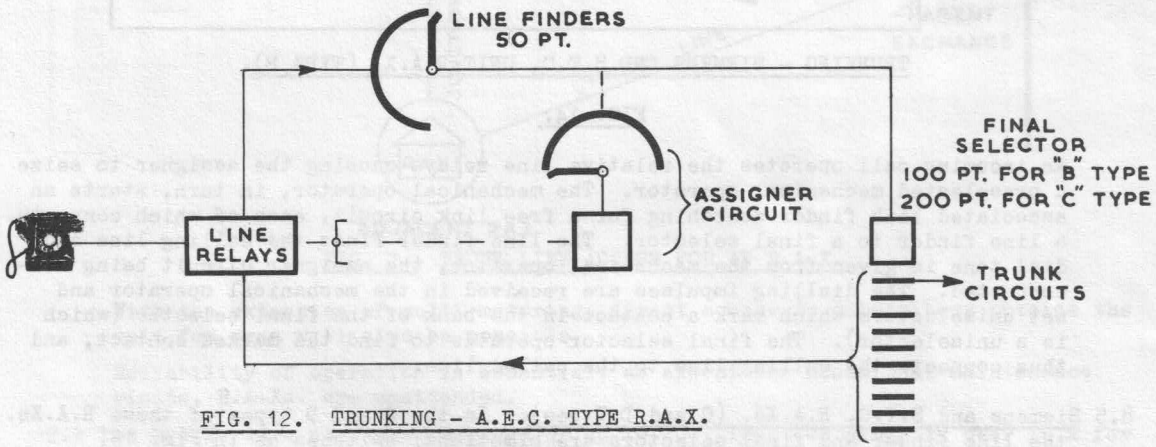


FIG. 12. TRUNKING - A.E.C. TYPE R.A.X.

8.3 G.E.C. Type R.A.X. The G.E.C. Unit employs similar trunking to the A.E.C. Unit, except that on the C and D types both group and final selectors are used. These switches are both 100 point. The use of group selectors allows the trunk circuits and special circuits to be additional to the 200 subscribers' lines and also allows extension beyond 200 lines. The trunking diagram of the G.E.C. Unit is shown in Fig. 13.

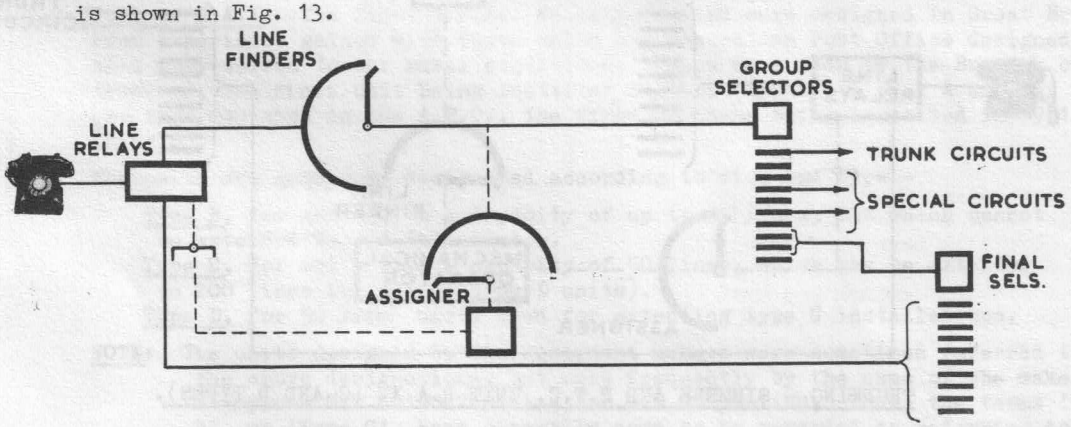
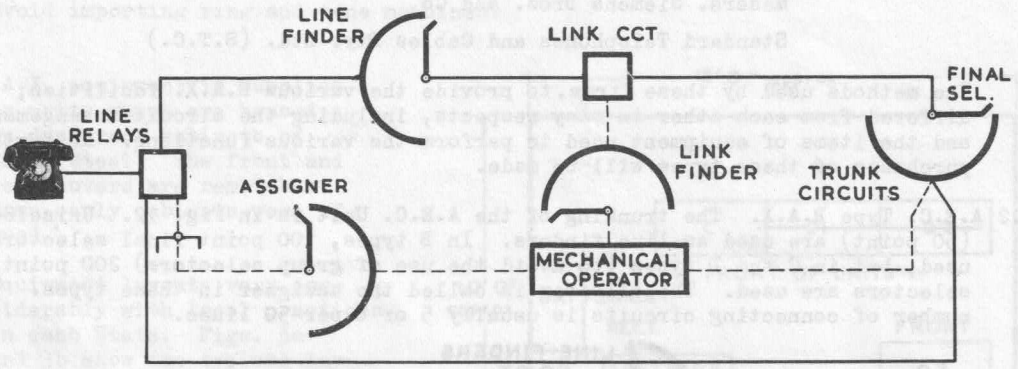


FIG. 13. TRUNKING - G.E.C. TYPE R.A.X.

8.4 Siemens and S.T.C. R.A.Xs. (B Type). These systems differ in that use is made of apparatus called a "Mechanical Operator" or "Controller". This is an assembly of uniselectors and relays, which receives particulars of the call and establishes the connection. The operator or controller then frees itself to undertake similar functions for the next call. Only 2 or 3 of these units are included in an installation, the number being determined by the amount of switching to be performed. The trunking diagram of this system is in Fig. 14.

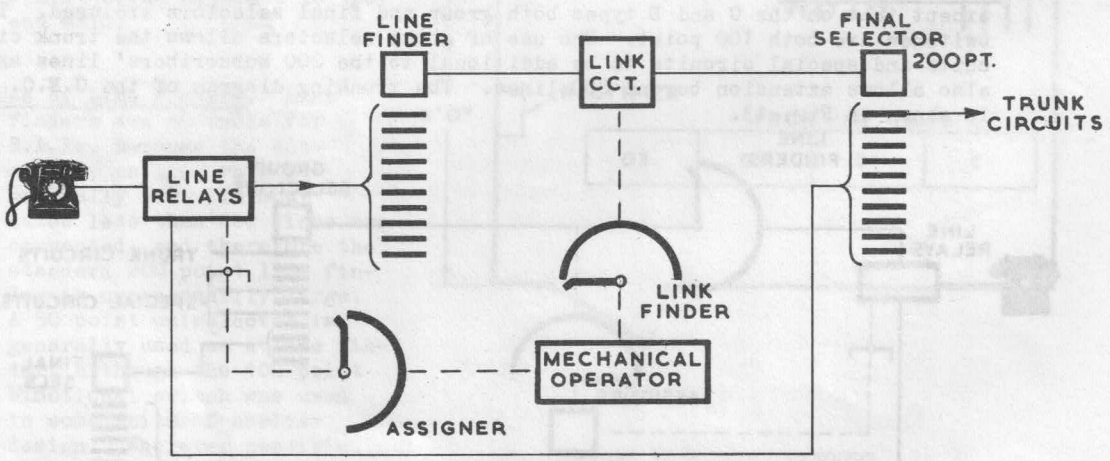


TRUNKING - SIEMENS AND S.T.C. UNIT R.A.X. (TYPE B).

FIG. 14.

An incoming call operates the relative line relays causing the assigner to seize a preselected mechanical operator. The mechanical operator, in turn, starts an associated link finder searching for a free link circuit, each of which connects a line finder to a final selector. The line finder finds the calling line and dial tone is given from the mechanical operator, the assigner circuit being disconnected. The dialling impulses are received in the mechanical operator and set uniselectors which mark a contact in the bank of the final selector (which is a uniselector). The final selector operates to find the marked contact, and thus connects the calling line to the called line.

8.5 Siemens and S.T.C. R.A.Xs. (C and D Types). In the C and D types of these R.A.Xs. the line finder and final selectors are bimotional switches as in Fig. 15.



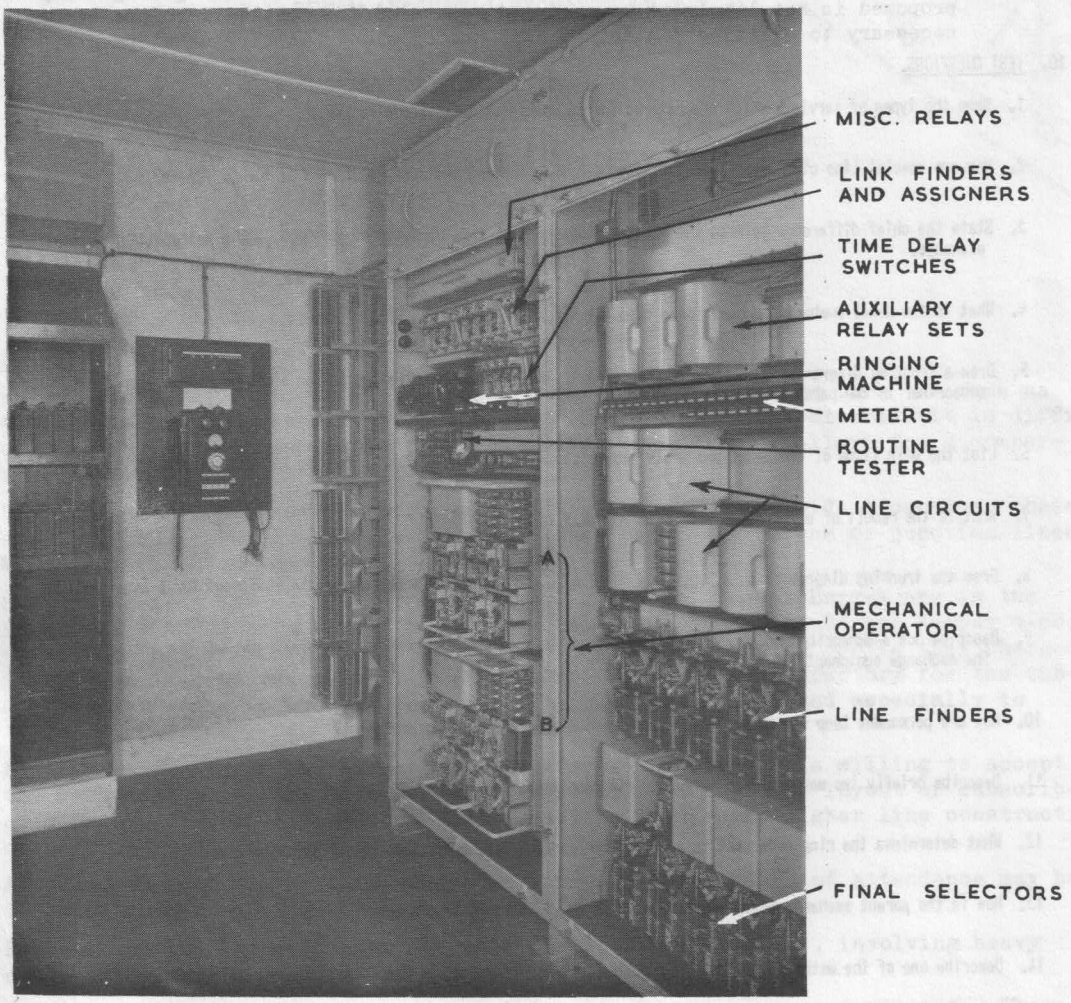
TRUNKING - SIEMENS AND S.T.C. UNIT R.A.X. (C AND D TYPES).

FIG. 15.

A call from a subscriber connected to this type of unit takes a route similar to that followed by a call through a B Type unit, except that the incoming pulses direct the 200 point final selector to the called line. At the same time, however, switches are set in the mechanical operator for discriminating on trunk circuits, public telephones, party lines, multi-office circuits, battery control, etc. Fig. 16 shows an R.A.X. of this type which includes two mechanical operators.

The mechanical operator also transmits ringing and tones, code calling on party lines or multi-office trunk circuits and supplies the metering pulse when the called subscriber answers. It then releases, to be available for further use, and the connection is maintained via the simple link circuit.

The system has the advantage of confining several switching functions to the common group of mechanical operators, but their disadvantage is that being common equipment, their failure results in the failure of the connecting circuits.



SIEMENS TYPE R.A.X.

FIG. 16.

9. FUTURE TRENDS.

9.1 Crossbar R.A.Xs. have been used in Australia and found successful. The inherent reliability and small space requirements of a crossbar system make it very suitable for R.A.Xs. More crossbar R.A.Xs. will be used in the future.

9.2 Remote testing and busying, are from past experience deemed to be desirable facilities. Where provided on occasions, remote testing of subscribers' lines has saved the Technicians and Linemen a considerable amount of travelling. A relatively simple remote test set will shortly be standardised for A.P.O. units, and provide facilities for testing subscribers' and trunk lines from the parent exchange. The same circuit may also include facilities to enable remote busying of trunk or junction lines, and 1st choice final selectors.

9.3 Multi-metering facilities will be provided in due course to enable the R.A.X. subscriber to be automatically switched beyond the unit fee boundaries. The standard A.P.O. Type B and C units have been designed with this end in view, and as can be seen in Fig. 7b, relay set cradles are provided and wired for the multi-metering relay sets. However, the type of multi-metering originally proposed is not likely to be used and some alteration will therefore become necessary to existing R.A.Xs. to suit nation-wide switching developments.

10. TEST QUESTIONS.

1. Name the types of services which are catered for by special R.A.X. line circuits.

2. How are special line circuits associated with both the line and switching equipment in A.P.O. R.A.Xs?

3. State the chief difference between the ordinary subscribers' line circuits of an R.A.X. and a metropolitan automatic exchange.

4. What is the usual numbering scheme for a type 'C' R.A.X?

5. Draw a trunking diagram of an A.P.O. Type 'C' R.A.X. and briefly describe the action of the equipment for a call from a subscriber to the parent exchange.

6. List the main items of equipment you would expect to see at an A.P.O. R.A.X. serving 130 subscribers.

7. What is the result of eliminating allotters from R.A.Xs?

8. Draw the trunking diagram of an A.P.O. Type 'B' R.A.X. and describe the action of the equipment for a local call.

9. Describe how a subscriber on an R.A.X. party line calls another party on the same line. Include the action of the exchange equipment.

10. How are permanent loop faults prevented from holding R.A.X. switching equipment?

11. Describe briefly two methods used to supply ring and tones for R.A.Xs.

12. What determines the ring code sent to a subscriber on an R.A.X. party line having three parties?

13. How is the parent exchange telephonist made aware that a call is from a public telephone?

14. Describe one of the methods used to bring alarm fault conditions at an R.A.X. to the notice of the Technician.

15. Describe one method of maintaining the power supply at an R.A.X. which is remote from any source of commercial power.

END OF PAPER.